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SULTAN DAM PROJECT, SNOHOMISH RIVER BASIN, WASHINGTON

Federal Water Pollution Control Administration
Portland, Oregon

August 1967

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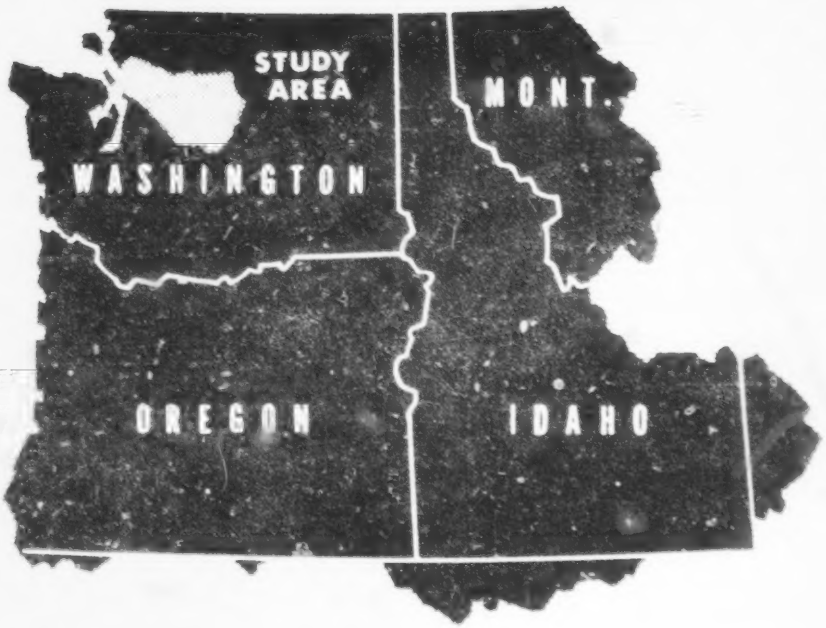

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WATER SUPPLY AND WATER QUALITY CONTROL STUDY

S U L T A N D A M P R O J E C T

S N O H O M I S H R I V E R B A S I N , W A S H I N G T O N

An investigation has been made which disclosed a need for storage in Skykomish River watershed to meet future water demands in the Everett urban area. A need for storage for water quality control is not foreseen at this time. Future water requirements and quality projections are based on economic, demographic, and engineering studies.

P r e p a r e d a t t h e R e q u e s t o f t h e

U. S. Army Engineer District, Seattle
Corps of Engineers, Seattle, Washington

B y t h e

U. S. Department of the Interior
Federal Water Pollution Control Administration
Northwest Region, Portland, Oregon

August 1967

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I. INTRODUCTION

A. REQUEST AND AUTHORITY

The District Engineer, U. S. Army Engineer District, Seattle, in a letter dated May 14, 1963, requested the advice of the U. S. Department of Health, Education, and Welfare concerning the needs for storage for water supply and water quality control in the proposed Sultan Project reservoir in the Skykomish River watershed, Snohomish River Basin, and the value of benefits resulting therefrom.

The water supply portion of this study was made in accordance with the Memorandum of Agreement, dated November 4, 1958, between the Department of the Army and the Department of Health, Education, and Welfare relative to the Water Supply Act of 1958, as amended (43 U.S.C. 390b). The water quality control aspects are considered under authority of the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et seq.). Responsibility for these activities was transferred from the Department of Health, Education and Welfare to the Department of the Interior by Re-organization Plan No. 2 of 1966, effective May 10, 1966.

B. PURPOSE AND SCOPE

This investigation was undertaken by the Federal Water Pollution Control Administration for the purpose of advising the Corps of Engineers on the need for and value of storage in the Skykomish River watershed for the purposes of municipal and industrial water supply and water quality control. To accomplish this, available data on water uses, waste sources, and water quality were examined, evaluated, and projected. Future needs were projected to the year 2020 with interim points at 1980 and 2000. An economic base study and forecast of future population and industrial growth was prepared for this purpose and is summarized in this report.

The study area covered in this report is comprised of the Skykomish and Sultan River watersheds and includes, for water supply purposes, the city of Everett.

C. ACKNOWLEDGMENTS

The preparation of this report was aided substantially by officials of the Washington Department of Conservation; Washington Department of Health; Washington Pollution Control Commission; Gray and Osborne, Consulting Engineers; Harstad and Associates, Consulting Engineers; the city of Everett, Washington; and the U. S. Army Engineer District, Seattle.

The use of information furnished in the references listed in the bibliography is also acknowledged.

II. SUMMARY of Findings and Conclusions

A. SUMMARY OF FINDINGS

1. The proposed Sultan Dam enlargement project is located on the Sultan River in the Central Puget Sound area of northwestern Washington approximately 17 river miles upstream from the confluence of the Sultan and Skykomish Rivers.

2. The Corps of Engineers' proposed project would be an enlargement of the dam for multi-purpose development. The proposed project would raise the elevation of the dam from 1,408 to 1,527 feet to provide a gross storage of 205,000 acre-feet for the purposes of flood control, additional water supply, fishery enhancement and power generation.

3. The average annual runoff of the Skykomish River as measured at the gaging station near Gold Bar, Washington (drainage area 535 square miles) is 2,792,000 acre-feet (3,850 cfs) for the 30-year period of record (1928-1958). For the same period of record, the annual average runoff of the Sultan River near Startup, Washington (drainage area 74.5 square miles) is 570 000 acre-feet (786 cfs). The one-in-ten year low, mean annual flow of the Skykomish River near Gold Bar and Sultan River near Startup is 2,681 cfs and 542 cfs, respectively. The mean monthly minimum flows for this recurrence interval for the Skykomish and Sultan Rivers are 756 cfs (September) and 122 cfs (August), respectively.

4. The economy of the Central Puget Sound area is largely dependent upon transportation equipment manufacturing and service industries in the Seattle vicinity, and pulp, paper, lumber and wood products manufacturing industries in the Everett area. In 1960, the population of the Central Puget Sound study area (King and Snohomish Counties) was 1,107,200.

5. The city of Everett presently obtains its water supply from Lake Chaplain and the Sultan River. The present safe, sustained yield of the water supply with Lake Chaplain and the first stage of the Sultan project is 170 mgd, based on the flows during the critical water year 1938. Present capacity of the transmission system is also 170 mgd.

6. In 1966 municipal and industrial water demands in the Everett urban area averaged 124 mgd. The Everett system presently serves approximately 155,000 persons along with two pulp and paper plants and a pulp plant. Present industrial water usage accounts for about 102 mgd. Average M&I demands for the urban area are forecast to increase to 262 mgd by 1980, 337 mgd by 2000, and 441 mgd by 2020.

7. Water quality in the Skykomish River watershed, including the Sultan River, is adequate for all uses (see Appendix, Table A-1).

8. The Everett water supply in Sultan River watershed is treated by disinfection only. By recent action, however, the Washington State Health Department has advised that the Sultan River watershed either be closed to public use for recreation or that Everett provide complete treatment of its supply.

9. At the present time, about 7.39 million population equivalents (PE) of organic waste are produced daily in the Skykomish-Snohomish-Port Gardner Bay area excluding the wastes produced by food processing operations. Of this amount, about 99 percent is attributable to the pulp and paper operations of Simpson Lee Paper Co., located on Ebey Slough, Weyerhaeuser Paper Co., located on the lower Snohomish River and Port Gardner Bay, and Scott Paper Co., located on Port Gardner Bay, all in the vicinity of Everett. During the food-processing season, it is estimated that the daily raw waste production in the study area is increased by approximately 100,000 PE.

10. At the present time, 2,720 PE are discharged to the Skykomish River watershed, 36,000 PE are discharged to the lower Snohomish River, and about 7,196,000 PE are discharged in the Port Gardner Bay area. Raw waste production in the Skykomish River watershed is projected to be 8,740 PE by 1980, 18,900 PE by 2000, and 49,480 PE by 2020.

B. CONCLUSIONS

1. Population of Snohomish County is projected to increase to 324,000 by 1980, 498,000 by 2000 and 759,000 by 2020. About 95 percent of this projected 2020 population is expected to reside within the Everett urban area. It is in this area that major water and waste problems relating to possible service by the proposed Sultan Project are and will continue to be centered.

2. The safe yield of Everett's supply on Sultan River will be reached about the year 1975, and it is estimated that new storage totalling about 94,600 acre-feet will be required to meet the projected 2020 demand.

3. With adequate waste treatment (at least 85 percent BOD reduction), sufficient streamflow (minimum flow of record 315 cfs--Skykomish River) for waste assimilation is expected to remain available downstream from Sultan Dam to maintain adequate quality conditions for all future uses. This is based on dissolved oxygen (DO) requirements for rearing of anadromous fish wherein 7 mg/l of DO can be maintained into the future with a minimum flow in Skykomish River of about 50 cfs. A draft-on-storage from Sultan Reservoir enlargement for this purpose, therefore, is not expected to be required. Maintenance of stream temperatures at or below 70°F during July and August and to 57°F other months would provide adequate conditions for fish rearing.

4. Adequate water quality can be maintained in Snohomish River estuary by removal of settleable solids from pulp and paper mill waste effluents.

5. The effect of untreated pulp and paper mill waste discharges to deep waters of Port Gardner Bay are currently being investigated by the FWPCA Puget Sound Enforcement Project. Recommendations with respect to needs for additional control in this bay area will be forthcoming from that study within calendar year 1967. Regulation of fresh water inflow to Snohomish estuary from Snohomish River would not, however, materially improve estuary or bay water quality.

6. The annual value of storage in the proposed Sultan Dam enlargement project, to yield 94,600 acre-feet (270 mgd sustained yield) of water for M&I purposes in the Everett urban area is estimated to be $417,000 ($1,550 per mgd). This value is based on the capital and investment cost of alternative single-purpose storage available to the Everett area in the absence of the Corps of Engineers' project, amortized over a 100-year period at 3.125 percent. Enlargement of Sultan Dam is the cheapest alternative and was used for this determination.

7. Adequate water quality for fisheries, recreation and other water uses can be maintained in Sultan and Skykomish Rivers by providing municipal and industrial waste treatment capable of at least 85 percent BOD reduction. As flow regulation cannot be used as a substitute for adequate waste treatment, no benefits assignable to the Sultan Project for water quality control are indicated at this time.

8. With adequate waste treatment, flow regulation for water quality control is not expected to be needed for at least 50 years. If, however, unforeseen future developments in the basin result in greater waste loads than those projected or in sustained minimum flows in the Skykomish River of less than 50 cfs, the adverse effects on water quality should be re-evaluated and necessary control measures instituted.

III. PROJECT DESCRIPTION

A. LOCATION

The Sultan Dam and reservoir project considered in this report is located on the Sultan River in northwestern Washington approximately 17 river miles upstream from the confluence of the Sultan and Skykomish Rivers. Based on 26 years of record (1934-1960), the average annual runoff of the Sultan River at the gaging station located 1.5 miles upstream from the intake of the Everett water supply (drainage area 74.5 square miles) and 4.9 miles downstream from the Sultan Dam (drainage area 68.3 square miles) is 794 cfs or 574,800 acre-feet.

The Snohomish River Basin encompasses a total area of 1,825 square miles in northeastern King County and southern Snohomish County. The main stem, 22 miles long, is formed at the confluence of the Skykomish River (drainage area, 843 square miles) and the Snoqualmie River (drainage area, 688 square miles). Headwaters of both rivers are located in the Cascade Mountains. The Sultan River, from the headwaters, flows easterly for about 15 miles and then turns almost due south, where it flows to the Skykomish River which in turn flows westerly to the Snohomish River at the town of Monroe (see the Location Map, back cover).

B. PROPOSED PROJECT

The first stage construction of Sultan Dam was recently completed. It was a joint effort of the city of Everett and the Snohomish County PUD #1. Sultan Dam was constructed to elevation 1,360 feet to provide 31,000 acre-feet of storage for water supply purposes. The Corps of Engineers' proposed project would be an enlargement of Sultan Dam for multi-purpose development. The elevation of the dam would be raised from 1,360 to 1,527 feet to provide a gross storage of 205,000 acre-feet for the purposes of flood control, additional water supply, fishery enhancement and power generation. It would provide 100 cfs (50 cfs during the summer months when the water demand is critical) initially available for fisheries which could be used at a later date for water supply. During the period November 1 to March 1 each year, when natural base flows in the river are high, the project would utilize flood control storage capacity. During other times of the year, this space could be used for water supply purposes.

IV. STUDY AREA DESCRIPTION

A. LOCATION AND BOUNDARIES

The study area is comprised of the drainage area of the Skykomish and Sultan River watersheds. The main stem of the Snohomish River has been previously discussed in connection with the North and Middle Forks Snoqualmie River Project investigation. For purposes of this report, discussion regarding the water supply aspects is concerned with the Everett urban area.

The economic base study area is comprised of King and Snohomish Counties, Washington.

The areas and stream reaches examined for water quality control purposes are the Sultan River below the project and the Skykomish River below the confluence of the Sultan and Skykomish Rivers.

B. PHYSICAL FEATURES

1. Geology and Soils

The Cascade Mountains are a north-south range marked by strong structural elements trending northwest-southeast. The rocks are a very complex assemblance of Cretaceous sediments, Miocene extrusives and intrusives with many older sediments and extrusives highly metamorphosed. The stream valleys were occupied by valley glaciers during the early Pleistocene age. The present bottom land deposits resulted from the action of the latest continental ice sheet. When this ice sheet occupied the Puget Trough, lower portions of valleys extending westerly from the Cascade Mountains were blocked. The rivers were dammed by glacial moraines causing large valley lakes to be formed. When the glacial ice melted, the rivers again extended to the sea, draining the valley lakes and building deltas into the estuaries which have been converted to flood plains in the valley bottoms as tidewater has been pushed back to its present position.

Much of the lower basin and portions of the upper valleys are underlain by deep glacial, glaciofluvial, and alluvial deposits. At the project site, the geologic structure consists of bedrock overlain with sand and clay layers and glacial till.

The soils of the mountainous areas consist of a thin mantle of glacial debris on the slopes, with considerable amounts of glacial drift on gentler slopes and the valley bottoms. Much of the soil is gravel and is not adapted to agricultural use.

2. Topography

Upper reaches of the Sultan and Skykomish River watersheds are characterized by mountain peaks and rugged foothills reaching altitudes of 6,000 feet. In the western portions of the study area, the topography is more rolling in nature with wider valleys. In its upper four miles, the Snohomish River flows through a narrow valley from one half to one mile in width, bordered on each side by hills that rise to an elevation of about 500 feet. Along the lower reaches of the stream the valley is from two to three miles wide, much of it consisting of marshes and lowland.

3. Climate

Because of the wide variation in elevations, the study area exhibits marked differences in climate. Mean temperatures range from about 50°F at the lower elevations to about 43°F in the mountains. Maximum temperatures of over 100°F at the lower elevations and minimum temperatures below zero at the higher elevations have been recorded. Average annual precipitation varies from over 100 inches in the mountains to about 35 inches in the lower elevations. Mean annual snowfall, which is generally less than ten inches in the lowlands, reaches 458 inches at Stampede Pass and 420 inches at Snoqualmie Pass. Approximately 75 percent of the yearly precipitation falls during the period October through March. The growing season varies from 165 days in northern Snohomish County to 240 days in southern King County.

C. PRINCIPAL COMMUNITIES

The city of Everett, 1960 population of 45,380, is the largest urban center within the study area. The non-urban areas of the Snohomish-Skykomish basin contain other relatively small communities such as Snohomish (3,900), Monroe (1,901), Sultan (821), Startup (250), Gold Bar (315), and Index (158).

V. WATER RESOURCES of the Study Area

A. SURFACE WATER

1. Existing Water Resource Development

Water resource development in the Snohomish-Skykomish River Basin has been minimal in the past. The Snohomish County PUD #1 and the city of Everett recently completed the first stage of the Sultan Project on the Sultan River which provides 31,000 acre-feet of storage for water supply. Lake Chaplain, originally a natural lake, has been enlarged through the years to its present capacity of 4.35 billion gallons (13,300 acre-feet) so as to meet the needs of the growing industrial community. Water is diverted from the Sultan River Diversion Dam to Lake Chaplain via a 7,064-foot tunnel. In addition to these project developments, some local flood control and navigation works are under way or have been completed in the lower basin.

2. Water Rights

Water rights in the entire Snohomish River Basin have been summarized by the Washington Department of Conservation. This summary as of 1962 lists 462 applications for diversions totalling over 5,600 cfs in the entire basin. Temporary permits have been granted to 442 of these applicants in the amount of almost 1,300 cfs. Three hundred sixty-two certified or permanent water rights have been issued for approximately 600 cfs.

Water rights in the Skykomish River watershed total 4,769 cfs. Applications account for 3,664 cfs of this amount with temporary permits and certified water rights accounting for 678 and 427 cfs, respectively. Water rights, consumptive and nonconsumptive, for the Skykomish River drainage are shown in TABLE V-1 and water rights for the city of Everett are shown in TABLE V-2.

TABLE V-1
WATER RIGHTS
SKYKOMISH RIVER WATERSHED

Stream	Application cfs	Permits cfs	Certified cfs
Skykomish-Main Stem	68.18	42.63	40.91
Sultan River	1,156.41	400.41	196.01
Skykomish-South Fork	1,696.64	192.64	188.64
Skykomish-North Fork	742.58	42.58	0.98
TOTALS	3,663.81	678.26	426.54

TABLE V-2
WATER RIGHTS
CITY OF EVERETT

Application	Permit	Certificate	Priority	Source	Quantity	Location	Division	Section	Use
5309	3213	1791	11/22/40	Chaplain Cr.	15.0	T28-R8E	SW¼NE¼	6	Municipal
R-2520	P-82	2463	2/14/29	Sultan R.	13,200 AF	T28-R7E	NE¼	6	"
2519	1322	460	2/14/29	Sultan R.	110.0	T29-R8E	W½	28	"
31	189	352	9/14/17	Sultan R.	20.0	T29-R8E	N½SE¼	32	"
1150	468	1790	7/31/24	Sultan R.	50.0	T29-R8E	N½SE¼	32	"
2759	2295		11/12/29	Sultan R.	200.0	T29-R8E	NW¼	33	"
13219			12/15/54	Sultan R.	200.0	T29-R8E	W½NW¼	33	"

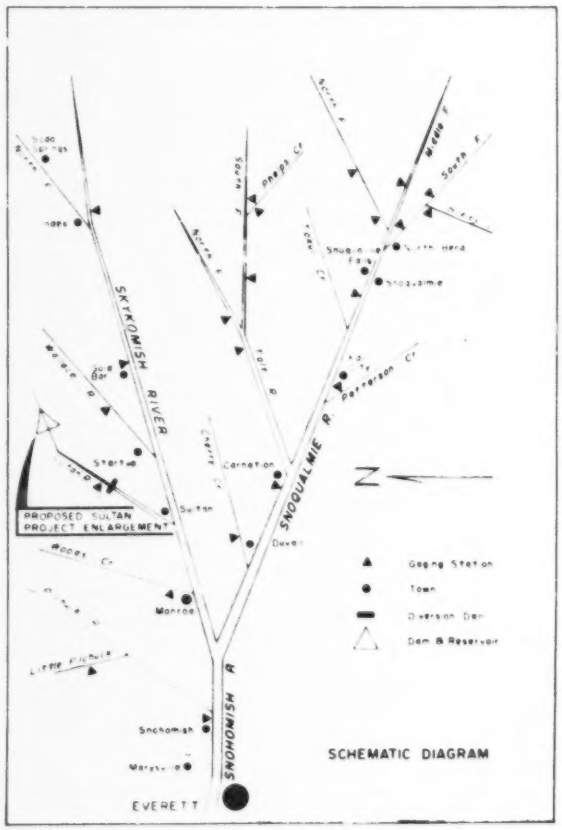

FIGURE 1

3. Streamflow Frequency Analysis

The Snohomish River usually has two high water periods each year. One, caused by heavy precipitation, occurs in the late fall or winter months and the other, caused by melting snow, occurs in late spring. Low flows usually occur in the months of August or September with a second low flow period occurring in early spring.

More than 20 stream gaging stations are currently operating in the Snohomish River Basin with some records having been started as early as 1898 (see Schematic Diagram, FIGURE 1). Although a station is located near the mouth of the Snohomish River at the town of Snohomish, tidal fluctuations make it impractical to compute flows below 10,000 cfs.

In the Skykomish River drainage, the best indicators of discharge are the stations located on the Skykomish River near Gold Bar (drainage area 535 square miles) and on the Sultan River near Startup (drainage area 74.5 square miles). The average discharge of the Skykomish and Sultan Rivers at these stations for the period 1928-1958 was 3,850 cfs and 786 cfs, respectively. Records at these stations for the period 1928 through 1958 were analyzed in the determination of the once-in-ten year low flow. The distribution of annual mean low flows that may be expected to occur at these stations, for recurrence intervals of 5, 10, and 20 years is shown in TABLE V-3.

TABLE V-3
EXPECTED MONTHLY FLOWS IN CFS
FOR VARIOUS RECURRENCE INTERVALS

MONTH	SULTAN RIVER NEAR STARTUP			SKYKOMISH RIVER NEAR GOLD BAR		
	1/5 Year	1/10 Year	1/20 Year	1/5 Year	1/10 Year	1/20 Year
Jan.	702	591	586	2824	2510	2345
Feb.	638	537	528	2650	2360	2200
Mar.	584	491	483	2320	2060	1928
Apr.	799	672	666	3710	3300	3080
May	1028	856	842	5750	5140	4800
June	815	686	675	5190	4610	4310
July	360	304	298	2380	2120	1982
Aug.	141	122	120	879	781	729
Sept.	215	181	178	851	756	706
Oct.	632	532	522	2250	2000	1865
Nov.	850	716	704	3310	2940	2745
Dec.	973	819	805	3890	3460	3230
MEAN	644	542	533	3020	2681	2505

4. Quality of Water Available

Quality of surface waters of the Snohomish River Basin has been measured on a routine basis since July 1960 as part of a cooperative State-Federal basic data program. This program is conducted by the Washington Department of Conservation, the Washington Pollution Control Commission and the U. S. Geological Survey. Sampling was initiated on the Skykomish River near Gold Bar in July 1959 and on the Sultan River at Sultan in July 1960.

Selected water quality data for these stations in the Skykomish River watershed are presented in Appendix A, Table A-1.

Phosphate concentrations for the Sultan River at Sultan are generally slightly higher than those for the Skykomish River near Gold Bar. Values in the Sultan River have ranged up to 0.07 mg/l, much higher than the threshold limit of 0.03 mg/l, for stimulation of growth of aquatic organisms. In the Skykomish River, phosphate concentrations are closer to the threshold limit.

MPN values in the Skykomish River and Sultan River are relatively low. In the Sultan River, the highest recorded[1/] MPN value was 930. In the Skykomish River, a MPN value of 2,400 has been recorded. MPN values greater than 1,000 coliforms per 100 ml would be undesirable for water contact activity.

Based on water temperature data recorded for the Sultan River at Sultan, maximum temperatures are in the order of 65°F.

B. GROUNDWATER

Groundwater quality data for the Skykomish and Sultan River watersheds are limited. Available data for the Snohomish Basin indicate water generally low in dissolved solids, soft to moderately hard, and having very little color.

Water quality data for selected wells in Snohomish County are presented in Appendix A, Table A-2.

[1/] Based on USGS and WPCC data for the period of record July 1960 to August 1965.

VI. THE ECONOMY

A. GENERAL

The demand for water for municipal and industrial purposes, and the amount and character of waste waters resulting from such uses, are determined largely by the activities associated with a region's economic base. The purpose of this section is to present economic and demographic data to be used as a basis for projecting the needs for water for municipal and industrial purposes and for estimating the future amounts and types of waste and land drainage material that may be expected to occur in the Central Puget Sound Area with the expanded development anticipated in the future.

B. PRESENT

1. Economic Activities

King and Snohomish Counties, referred to in this report as the Central Puget Sound Area, include the Seattle-Everett urban center, the largest population cluster in the Pacific Northwest. Seattle is the metropolitan service center for a large region comprising most of western Washington and parts of eastern Washington. Important transportation service industries are associated with the Port of Seattle. The manufacturing sector is dominated by the Boeing Company, with substantial manufacturing employment also in pulp and paper and lumber and wood products.

In the King and Snohomish two-county area, the total labor force in 1960 was 451,700, of which 116,800 were employed in manufacturing. About half of all manufacturing employment is in transportation equipment, the classification which includes the Boeing Company. The degree of specialization in this class of

manufacturing increased markedly during the 1950-60 decade. As is shown in TABLE VI-1, 29 percent of all manufacturing employment was in this category as of April 1, 1950, and 48 percent as of April 1, 1960.

TABLE VI-1

EMPLOYMENT, BY INDUSTRY, KING AND SNOHOMISH COUNTIES

(Employment in thousands)

Industry	1950 Employment			1960 Empl.	Change in Employ't 1950 - 1960
	King Co.	Snoho-mish Co.	King+ Snoho-mish Cos.	King+ Snoho-mish Cos.	+ Cos.
Agriculture	4.6	2.5	7.1	9.4	-2.3
Forestry and fisheries	1.0	.3	1.3	2.4	-1.1
Mining	.4	.1	.5	.9	- .4
Manufacturing, Total	100.4	16.4	116.8	67.7	+ 49.1
Lumber, wood prods., furn. fix.	5.9	5.5	11.4	13.0	-1.6
Primary metals	2.5	.2	2.7	2.9	- .2
Fabricated metals	5.2	.6	5.8	3.5	+2.3
Machinery, non-electric	3.7	.6	4.3	2.9	+1.4
Electrical machinery	2.4	.3	2.7	.9	+1.9
Motor vehicles, equip.	2.0	.1	2.1	1.1	+1.0
Other transp., fair, water, rail)	52.8	2.8	55.6	19.6	+ 36.0
Other durables	4.1	.7	4.8	2.9	+1.9
Food and kindred	8.8	1.3	10.1	8.1	+2.0
Textiles	.3	- [a]	.3	.4	- .1
Apparel	2.4	.1	2.5	1.9	+ .6
Printing and publishing	6.1	.8	7.1	5.2	+1.9
Chemicals	1.5	.1	1.6	1.4	+ .2
Other non-dur., and misc.[b]	2.5	3.1	5.8	4.0	+1.8
Construction	21.7	4.7	25.4	23.1	+2.3
Transportation, Total	20.9	2.7	23.6	23.3	+ .3
R. R. Transportation	4.2	.8	5.0	6.3	-1.3
Trucking, warehousing	5.2	.7	5.9	4.4	+1.5
Other (air, water transp.)	11.5	1.2	12.7	12.6	+ .1
Communications, Utilities	9.9	1.7	11.6	9.8	+1.8
Wholesale trade	19.1	2.0	21.1	16.8	+4.3
Retail trade	54.6	4.5	60.1	58.6	+5.5
Finan., Insur., Real Est.	21.4	2.1	23.5	17.4	+6.1
Busin., & Repair Services	9.7	1.4	11.1	9.9	+1.2
Personal Services[c]	21.7	3.5	25.2	23.2	+2.0
Education	20.6	3.1	23.7	12.9	+ 10.8
Professional & Related Serv.[d]	27.2	3.5	30.7	19.2	+ 11.5
Public Administration	16.6	2.2	18.8	20.1	-1.2
Industry not reported	13.9	1.5	15.4	4.3	+ 11.1
Total Employed, civilian	362.7	57.2	419.9	318.9	+101.0
Unemployed	21.2	4.5	25.7	25.5	+0.2
Military	4.7	1.4	6.1	10.0	-3.9
TOTAL LABOR FORCE	388.6	63.1	451.7	354.4	+ 97.3

[a] Less than 50 persons.
[b] Includes paper, pulp, petroleum refining, rubber and leather products.
[c] Includes private household workers, hotel and lodging places, and other personal services, and entertainment and recreation.
[d] Includes hospitals, welfare and nonprofit organizations, medical and related, and other professional services.
Source: U. S. Census of Population

During the 1950-60 decade, 49,000 new jobs were established in manufacturing, and 36,000 of those were in transportation equipment, principally at the Boeing Company. Modest increases in other manufacturing categories were, to some degree, related to production of material for Boeing, indicating the company's influence on the area's economic base.

The dominance of transportation equipment manufacturing in the area's economic base can also be seen in TABLE VI-2. More than 12 percent of the entire labor force is in this category, whereas in the United States as a whole, the comparable figure is only 1.4 percent. The percentage of the total labor force in all types of manufacturing was about the same in the King-Snohomish two-county area as in the United States. The only other manufacturing category in which the two-county area has any degree of specialization, relative to the United States as a whole, is lumber and wood products. There are, of course, specializations in terms of smaller classifications than those in TABLE VI-2. For example, pulp and paper manufacturing, located at Everett, is an important specialization of the two-county area, but this activity is classed with "other nondurables" (following the procedure of the U. S. Census Bureau), and in that classification as a whole, employment in the two-county area is below the national average.

TABLE VI-2
PERCENTAGE DISTRIBUTION OF EMPLOYMENT, BY INDUSTRY
KING AND SNOHOMISH COUNTIES

Industry	King + Snohomish Co's. 1950	1960	U.S. 1960
Agriculture	2.7	1.6	6.1
Forestry and Fisheries	.2	.1	.1
Mining	.2	.1	.9
Manufacturing, Total	19.1	25.9	25.1
Lumber & wood prod. (ind., Furn., Fix)	3.7	2.5	1.3
Primary metals	.8	.6	1.8
Fabricated metals	1.0	1.3	1.8
Machinery, nonelectric	.8	.9	2.3
Electrical machinery	.2	.6	2.1
Motor vehicles, equip.	.1	.5	1.2
Other transp., eq.(air, water, rail)	5.6	12.1	1.4
Other durables	.8	1.1	2.0
Food and kindred	2.1	2.2	2.6
Textiles	.1	.1	1.4
Apparel	.5	.6	1.7
Printing and publishing	1.3	1.6	1.6
Chemicals	.6	.1	1.2
Other non-dur., and misc. [a]	1.1	1.1	2.5
Construction	6.3	5.6	5.5
Transportation, Total	6.6	5.2	3.9
S.R. Transportation	1.8	1.1	1.1
Trucking, warehousing	1.2	1.3	1.3
Other (air, water transp.)	3.6	2.8	1.3
Communications, Utilities	2.8	2.6	2.5
Wholesale Trade	4.1	4.7	5.2
Retail Trade	16.3	14.2	11.7
Finan., Insur., Real Est.	4.9	5.2	3.9
Busin., & Repair Services	2.8	2.4	2.1
Personal Services [b]	6.6	5.6	6.2
Education	4.7	5.2	4.8
Professional and related serv. [c]	5.4	6.8	6.0
Public Administration	5.6	4.2	4.6
Industry not reported	1.2	1.4	3.7
Total Employed, Civilian	90.0	91.0	92.5
Unemployed	7.2	5.7	5.0
Military	2.8	3.3	2.5
TOTAL LABOR FORCE	100.0	100.0	100.0

[a] Includes paper, pulp, petroleum refining, rubber and leather products.
[b] Includes private household workers, hotel and lodging places, and other personal services, and entertainment and recreation.
[c] Includes hospitals, welfare and nonprofit organizations, medical and related, and other professional services.
Source: U. S. Census of Population.

Aside from manufacturing, other specializations of the two-county area include air and water transportation, wholesale trade, and financial, educational and professional services.

2. Population

The 419,900 civilian jobs itemized in TABLE VI-1 were, as of April 1, 1960, the principal economic support for a population of 1,107,200 persons in the two-county area. TABLES VI-3

TABLE VI-3
POPULATION OF COMMUNITIES IN KING COUNTY

City or Area	Population 1960	Population 1950
PORTION OF KING COUNTY INSIDE SEATTLE URBAN AREA COMMUNITIES		
Algona	1,311	n.a.
Auburn	11,933	6,497
Beaux Arts	351	n.a.
Bellevue	12,809	n.a.
Bothell	2,237	1,019
Clyde Hill	1,871	n.a.
Des Moines	1,987	n.a.
Duvall	345	236
East Richmond	203	n.a.
Houghton	2,426	1,005
Hunts Point	428	n.a.
Issaquah	1,870	955
Kent	9,017	3,278
Kirkland	6,025	4,713
Medina	2,285	n.a.
Normandy Park	1,224	n.a.
Pacific	1,527	n.a.
Redmond	1,426	573
Renton	18,453	16,039
Seattle	557,087	467,591
Tukwila	1,804	800
Yarrow Point	766	n.a.
TOTAL IN COMMUNITIES INSIDE URBAN AREA	639,439	n.a.
OTHER POPULATION (RURAL ETC.) INSIDE URBAN AREA	265,408	n.a.
TOTAL POPULATION INSIDE URBAN AREA	904,847 a/	n.a.
PORTION OF KING COUNTY OUTSIDE SEATTLE URBAN AREA COMMUNITIES		
Black Diamond	1,026	n.a.
Carnation	490	n.a.
Enumclaw	3,269	2,288
North Bend	965	287
Skykomish	166	491
Snoqualmie	1,216	806
TOTAL IN COMMUNITIES OUTSIDE URBAN AREA	7,132	n.a.
OTHER POPULATION (RURAL, ETC.) OUTSIDE URBAN AREA	22,859	n.a.
TOTAL POPULATION OUTSIDE URBAN AREA	30,171	n.a.
TOTAL POPULATION, KING COUNTY	935,014	732,992

a/ From preliminary, unpublished material by Puget Sound Regional Transportation Study.

TABLE VI-4
POPULATION OF COMMUNITIES IN SNOHOMISH COUNTY

City or Area	Population 1960	Population 1950
PORTION OF SNOHOMISH COUNTY INSIDE URBAN AREA COMMUNITIES		
Beverly Park (uninc.)	1,950	n.a.
Edmonds	8,016	2,057
Everett	40,304	11,849
Fairmont (uninc.)	1,227	n.a.
Intercity (uninc.)	1,475	n.a.
Lake Stevens (uninc.)	1,538	n.a.
Lowell (uninc.)	1,086	n.a.
Lynnwood	7,207	n.a.
Marysville	3,117	2,259
Mount Lake Terrace	9,122	n.a.
Mukilteo	1,128	826
Pinehurst (uninc.)	3,989	n.a.
Shoultes (uninc.)	1,159	n.a.
Snohomish	3,894	1,094
Woodway	713	n.a.
TOTAL IN COMMUNITIES INSIDE URBAN AREA	87,925	n.a.
OTHER POPULATION (RURAL ETC.) INSIDE URBAN AREA	49,944	n.a.
TOTAL POPULATION INSIDE URBAN AREA	137,869 a/	n.a.
PORTION OF SNOHOMISH COUNTY OUTSIDE URBAN AREA COMMUNITIES		
Arlington	3,025	1,615
Darrington	1,272	921
East Stanwood	477	378
Gold Bar	315	305
Granite Falls	599	635
Index	138	211
Monroe	1,901	1,556
Stanwood	646	710
Sultan	823	814
TOTAL IN COMMUNITIES OUTSIDE URBAN AREA	9,214	n.a.
OTHER POPULATION (RURAL ETC.) OUTSIDE URBAN AREA	26,116	n.a.
TOTAL POPULATION OUTSIDE URBAN AREA	35,330 a/	n.a.
TOTAL POPULATION, SNOHOMISH COUNTY	173,199	111,980

a/ From preliminary, unpublished material by Puget Sound Regional Transportation Study.

and VI-4 show that in 1960, about 97 percent of the total King County population was within urban areas while for Snohomish County, 80 percent was within urban areas.

C. PROJECTED ECONOMIC BASE AND POPULATION

1. Factors Influencing Future Growth

The future growth of the Central Puget Sound Area depends upon the further development of industry which is now the foundation of the economic base. Future production in transportation equipment manufacturing, the most important industry group in terms of total employment, depends largely on obtaining military contracts and commercial aircraft orders

by the Boeing Company. The record of this company suggests that average employment in this category during the study period will not decrease, except for short-run production adjustments, and may increase substantially.

The timber resource available for processing may continue at about the present level, with improved utilization and management offsetting the loss of acreage. However, the use of the basic resource is expected to alter, with a decrease in sawed lumber and increases in plywood, particle board, and pulp and paper manufacturing.

Employment in transportation services, especially in connection with the Port of Seattle, should increase in the future as well as employment in the other service industries which are now an important part of the economic base, particularly wholesale trade, finance, professional services, and education. Service industry employment related to tourism is also expected to become an increasingly important part of the economic base in the future.

2. Projected Industrial Activity

Because of this study's orientation towards water supply and pollution control problems, only those industries expected to have an impact on the water resources of Snohomish County have been considered. These industries are, generally, food processing, pulp and paper manufacturing, and certain chemical manufacturing industries, notably petroleum refining. It is not anticipated that food processing will become a significant part of the economic base of Snohomish County, particularly since there is a trend towards locating food processing and packaging closer to agricultural production. Therefore, this study is primarily concerned with the other two water-using industries--pulp manufacturing and petroleum refining.

A major pulp producing center has developed at Everett, the only location of pulp production in the King-Snohomish area. As shown in TABLE VI-5, the capacity of these mills totals 1,600 tons of pulp per day.

TABLE VI-5
PULP MILL CAPACITY, KING-SNOHOMISH AREA, 1966

MILL OWNER	TYPE OF PROCESS	TONS/24 HOURS
Scott Paper Company	Sulfite	850
Simpson Lee Logging Company	Sulfate	80
Weyerhaeuser Company	Sulfite	350
Weyerhaeuser Company	Sulfate	325
Total		1,605

It has been estimated that total pulp consumption in the United States may double between 1960 and 1980, and double again between 1980 and 2000. This would represent an annual compound rate of increase of about 3.5 percent. The rate of growth in consumption of pulp per capita in the United States during the past decade suggests that an even higher rate of increase may occur. Pulp mills throughout the United States must expand to meet the increased demand; however, in the case of the mills in the Puget Sound area, a limiting factor on growth of production is the supply of raw materials for pulping. At present, a large part of the raw materials processed in the area is imported from other areas in Washington, with a small amount coming from Canada. Since the area timber resource available for processing is expected to continue at about the present level, with some increase in materials for pulp and paper manufacturing, continued growth of Puget Sound area forest products industries will depend on the availability of increased supplies of raw materials from outside the Basin.

According to the U. S. Forest Service, in a report entitled "Prospective Timber Supplies and Forest Industrial Development in the Puget Sound and Adjacent Waters Area", the output of pulp mills in the area studied will increase sharply (4.5% compounded annually) between 1963 and 1980, will increase at a lower rate (1.6% annually) between 1980 and 2000, and will increase at a nominal 0.4% annually between 2000 and 2020. Assuming the mills at Everett will enlarge, or new ones develop, to maintain the area's share of Puget Sound pulping capacity in the future, the capacity would increase from about 1,600 tons per day in 1966 to about 3,000 tons in 1980, 4,000 tons in 2000, and 4,400 tons in 2020. It is expected that all pulp capacity in the King-Snohomish County area will continue to be in the vicinity of Everett.

Petroleum refining has not yet been established to any extent in the King-Snohomish County area, although small asphalt producing plants exist at Edmonds and Richmond Beach. Two refineries at Anacortes, in Skagit County, and one at Ferndale, in Whatcom County, produce essentially all the petroleum products processed in the Pacific Northwest. The combined capacity of these three plants constituted 87 percent of the total capacity in the Pacific Northwest in 1964. In 1962, the total capacity of refineries in Washington and Oregon (161,100 barrels per day) was only 53 percent of the demand (304,000 barrels per day) for petroleum products in those two states that year. Assuming refining capacity in Washington and Oregon will grow to meet most of this demand and that most of the growth will occur in the Puget Sound area, there is potential for considerable expansion.

According to a study of the petroleum industry in the Pacific Northwest conducted for the Bonneville Power Administration in 1966, refining capacity is expected to grow from 179,600 barrels per calendar day (b/cd) in 1964 to 431,000 b/cd in 1980. These projections, which show a growth of about 5.6 percent per year, are based on the assumption that local crude oil production will be limited or non-existent, and that the crude oil will be imported. If oil reserves are found locally, the refining capacity would increase at a higher rate, estimated at 7.9 percent per year, between 1964 and 1980. Based on the demand projected to 2010 in this report, and extrapolating to 2020, refinery capacity in Washington and Oregon is estimated to total 700,000 b/cd by 2000 and 1,060,000 b/cd by 2020. These projections represent growth rates of 2.4 percent per year between 1980 and 2000, and 2.1 percent between 2000 and 2020.

In anticipation of future expansion in the Puget Sound area, Union and Richfield Oil Companies now hold large sites (1,000 or more acres each) for possible refineries near the Tulalip Indian Reservation, in Snohomish County, a few miles north of Everett, and Standard Oil of California holds a site of about 2,500 acres near Paine Field, southwest of Everett. The Richfield Oil Company has recently announced plans to build a refinery at their site. The size has not been disclosed as yet, but this development is very likely the first of several refineries to be constructed in Snohomish County, all of which will enlarge as the demand for petroleum products increases.

It is assumed, for purposes of this study, that refineries will be in operation at all three of these sites by 1980, and that they will grow at the rates projected for Washington and Oregon between 1980 and 2020. The sizes of existing major refineries in the area range from 39,000 to 63,500 b/cd of crude oil processed. Assuming the new plants will each have an initial capacity of about 50,000 b/cd, the refining capacity in the Everett area will total 150,000 b/cd in 1980, and increase to 243,000 and 370,000 b/cd by 2000 and 2020, respectively.

3. Projected Population

The projected population of Snohomish County, 1960 to 2020, is shown in TABLE VI-6. Projections to 1980 are based on those developed for the Snohomish, King, Pierce, and Kitsap four-county area by the Puget Sound task force for Comprehensive Water Resources Studies. For the period 1980-2020, projections developed by the Office of Business Economics were used as a base. The distribution of future population between urban and ex-urban areas has also been estimated and is included in TABLE VI-6.

TABLE VI-6
PROJECTED POPULATION OF SNOHOMISH COUNTY 1960-2020
(Populations in thousands - Growth rates as percent compounded per year)

	1960 Pop.	1960-80 Rate %	1980 Pop.	1980-2000 Rate %	2000 Pop.	2000-20 Rate %	2020 Pop.
Urban Area	138	2.9	243	2.8	423	2.7	721
Ex-Urban Area	34	4.4	81	-0.4	75	-3.5	38
TOTAL	172	3.2	324	2.2	498	2.1	759

VII. WATER REQUIREMENTS
Municipal & Industrial

A. HISTORIC AND PRESENT WATER USE

1. General

Water for municipal and industrial purposes in the study area is currently supplied by the city of Everett and many smaller systems developed by municipalities, water districts or associations, public utility districts, private water companies, and individual industries.

2. Everett Urban Area

a. Existing Source Development

Everett's entire water supply is obtained from the Sultan River watershed, an area of approximately 84 square miles. In July 1960, the city of Everett and Snohomish County PUD #1 entered into a contract for the joint development of storage in Sultan Basin. Under the contract, a dam on the Sultan River, to be constructed in two stages, would provide storage to satisfy a water demand of 170 mgd initially, and 320 mgd ultimately. The first stage of Sultan Dam, which stores some 31,000 acre-feet of water to meet this 170 mgd demand, has been completed. Water is released past Sultan Dam and diverted from the river downstream to Lake Chaplain, a natural lake which now serves as an impounding reservoir for the Everett water supply. Active capacity of the lake is 4.35 billion gallons (13,300 acre-feet).

The developed capacities of Everett's water supply source and transmission facilities are both 170 mgd.

b. Municipal Water Use

Based on water consumption data provided by the city of Everett for the three-year period 1960-1962 and the seven-month period March-September 1966, the present average annual water demand on the Everett facilities has been determined to be approximately 16 mgd. This figure includes the usage categories of municipal, domestic, commercial, and some small industrial usage which may be included in the determination. In 1966, total usage outside the city limits averaged 5.6 mgd, the major portion of which was attributable to the Alderwood Manor Water District, which includes the cities of Mountlake Terrace, Brier, Lynnwood, and part of Edmonds.

The demand profile has been determined from water consumption for the years 1960-1962. For those areas outside the city limits, the same demand profile has been assumed. The monthly distribution of estimated present municipal water usage for the Everett urban area is shown in TABLE VII-1.

TABLE VII-1
MUNICIPAL WATER CONSUMPTION, MGD
EVERETT URBAN AREA

Month	Demand Profile % of Annual Average	Estimated 1966 Water Usage mgd	Water Usage Outside City Limits (1966) mgd	Total Water Usage mgd	Per Capita Usage 2/ gpcd
January	94	15.0	5.3	20.3	150
February	98	15.7	5.5	21.2	157
March	96	15.4	5.4	20.8	154
April	100	16.0	5.6	21.6	160
May	97	15.5	5.4	20.9	154
June	99	15.8	5.6	21.4	159
July	101	16.2	5.6	21.8	161
August	110	17.6	6.2	23.8	176
September	104	16.7	5.8	22.5	167
October	102	16.3	5.7	22.0	163
November	101	16.2	5.6	21.8	161
December	100	16.0	5.6	21.6	160
Average	---	16.0 1/	5.6 1/	21.6	160

1/ Distributed according to demand profile for the city of Everett.
2/ Based on a served population of 135,000.

The Everett water system presently serves about 155,000 persons, including the towns of Snohomish and Monroe (combined populations of about 8,500). Allowing for the recent additions of these two towns, and the sharp increase in population experienced in the Everett urban area the last two years, it is estimated the average population served during 1966 was about 135,000.

Exclusive of the demand exerted by the pulp and paper industry, Everett supplies about 90 percent of the municipal water requirements in the urban area. The remainder is supplied by separate facilities of the several communities and water companies.

c. Industrial Water Use

The major industrial water demands generated in the Everett urban area are attributable to the pulp and paper industry. Three of the four pulp and paper plants located in the area obtain water from the Everett system under contract agreement. A comparison of the contract demand with present usage by the plants is shown in the following table:

Industrial Plant	Contract Demand mgd	Average Annual Usage mgd
Scott Paper Co. (pulp & paper)	67	65
Weyerhaeuser Co. (sulfite pulp)	28	27
Simpson Lee Co. (pulp & paper)	12	10
TOTAL	107	102

In addition to the sulfite pulp mill located on Port Gardner Bay, the Weyerhaeuser Company also has a sulfate pulp mill in Everett which obtains its water (average use 32 mgd) from the Snohomish River. This is the only remaining major industrial process water user with a private source of supply.

Total production capacity of the four mills is approximately 1,600 tons/day. Average water use per ton of pulping capacity per day is about 84,000 gallons.

B. FUTURE WATER DEMANDS

1. Municipal

In the future, essentially all the urban area population will be supplied by surface water sources developed by the city of Everett.

Future per capita demands on the Everett system are expected to increase at about the same rate as the metered Seattle system. Utilizing the per capita demand increases projected for Seattle, the Everett use is expected to increase from 160 gpcd in 1966 to 175 gpcd in 1980, 195 gpcd in 2000, and 215 gpcd in 2020. Applying these per capita demand figures to the Everett urban population projections shown in TABLE VI-6, the future municipal water demands on the Everett system are estimated as shown in TABLE VII-2.

TABLE VII-2
FUTURE MUNICIPAL WATER DEMANDS
EVERETT URBAN AREA

Year	Population	Per Capita Demand gpd	Municipal Water Demand mgd	acre-feet
1980	243,000	175	43	48,000
2000	423,000	195	82	92,000
2020	721,000	215	155	174,000

The projected average annual municipal water demand has been distributed on a monthly basis, utilizing the demand profile developed for the Everett water system as shown in TABLE VII-1. These projected monthly water demands are shown in TABLE VII-3.

TABLE VII-3
PROJECTED MUNICIPAL WATER DEMANDS
EVERETT URBAN AREA

Month	Demand Profile % of Annual Ave.	1980 mgd	2000 mgd	2020 mgd
January	94	40	77	146
February	98	42	80	152
March	96	41	79	149
April	100	43	82	155
May	97	42	79	150
June	99	43	81	153
July	101	43	83	157
August	110	47	90	171
September	104	45	85	161
October	102	44	84	158
November	101	43	83	157
December	100	43	82	155
AVERAGE		43	82	155

2. Industrial

Future industrial water demands exerted on the Everett water system are expected to be generated primarily by the pulp and paper and oil refining industries. The bulk of these needs is presently satisfied by the Everett Water Department. Assuming that more efficient use of fresh water will be made by new or replacement mills to be built in the future, demands have been projected on the basis of lower unit water demands than are used at present.

All industrial demands, including industries such as the Weyerhaeuser sulfate plant that are self-supplied at present, are expected to be satisfied by the Everett facilities.

Industrial water demands for pulp and paper processing average about 84,000 gallons per ton of plant capacity per day at present. In the future, as fresh water supplies become limited and waste flows are subjected to more severe restrictions, unit water use for pulp and paper production is expected to decrease. In estimating the future needs for process water in pulp mills, the requirements per ton of plant capacity is expected to decrease to 70,000 gallons by 1980 and 60,000 gallons by 2000, and remain constant at 60,000 gallons thereafter.

Fresh water use at the two modern refineries located at Anacortes presently averages 67 gallons per barrel of refinery capacity per calendar day. By 1980, this requirement is expected to decrease to 60 gallons per barrel of capacity. Demands expected for the oil refining industry are assumed to be satisfied by the city's facilities either directly or through one of the water districts supplied by Everett.

Industrial demands are assumed to remain constant throughout the year. A summary of the projected major industrial water demands is presented in TABLE VII-4.

TABLE VII-4
PROJECTED INDUSTRIAL WATER DEMANDS

	Pulp and Paper			Oil Refining		Total	
		Unit Use		Proj. Capacity			AF/Yr.
Year	Tons	1000 gals/ton	mgd	1000 barrels/day	mgd 1/	mgd	1000's
1980	3000	70	210	150	9	219	245
2000	4000	60	240	240	15	255	285
2020	4400	60	264	370	22	286	320

1/ Based upon 60 gal/barrel of refinery capacity.

C. WATER SUPPLY REQUIREMENTS

The safe yield of Everett's present supply (170 mgd) will be reached by about 1975, and an additional 270 mgd will be required to meet the average annual demand of 440 mgd projected for 2020. As shown in TABLE VII-5, storage drafts from Sultan Project totalling 33,100 acre-feet by 1980, 63,400 acre-feet by 2000, and 122,600 acre-feet by 2020 would be needed to meet this additional demand. Actual required storage space would be less than this since the February and March storage drafts would be replaced by spring runoff normally occurring in April and May. Allowing for replacement of February and March drafts, new storage in Sultan Project totalling 26,500 acre-feet in 1980, 50,400 acre-feet in 2000, and 94,600 acre-feet in 2020 is expected to be required.

TABLE VII-5
FUTURE MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS
EVERETT FACILITIES - MGD

	1980						2000						2020					
	Demand			Available Safe Yield[1]	Draft Requirement		Demand			Available Safe Yield[1]	Draft Requirement		Demand			Available Safe Yield[1]	Draft Requirement	
Month	Munic	Ind	Total		Mgd	AF/Mo	Munic	Ind	Total		Mgd	AF/Mo	Munic	Ind	Total		Mgd	AF/Mo
January	40	219	259	519	--	---	77	255	332	519	--	---	146	286	432	519	--	---
February	42	219	261	184	77	6,600	80	255	335	184	151	13,000	152	286	438	184	254	21,800
March	41	219	260	370	--	---	79	255	334	370			149	286	435	370	65	6,200
April	43	219	262	970	--	---	82	255	337	970	--	---	155	286	441	970	--	---
May	42	219	261	615	--	---	79	255	334	615	--	---	150	286	436	615	--	---
June	43	219	262	312	--	---	81	255	336	312	24	2,200	153	286	439	312	127	11,700
July	43	219	262	170	92	8,800	83	255	338	170	168	16,000	157	286	443	170	273	26,000
August	47	219	266	170	96	9,100	90	255	345	170	175	16,600	171	286	457	170	287	27,300
September	45	219	264	170	94	8,600	85	255	340	170	170	15,600	161	286	447	170	277	25,500
October	44	219	263	401	--	---	84	255	339	401	--	---	158	286	444	401	43	4,100
November	43	219	262	1,230	--	---	83	255	338	1,230	--	---	157	286	443	1,230	--	---
December	43	219	262	790	--	---	82	255	337	790	--	---	155	286	441	790	--	---
AVERAGE	43	219	262	--	--		82	255	337	--	--		155		441	--	--	
TOTAL ANNUAL DRAFT-ON-STORAGE						33,100						63,400						122,600

[1] Monthly mean flows recorded during the critical water year of 1938. The water year 1938 taken as critical on the basis of low mean August and September flows. The safe yield of 170 mgd is greater than the recorded monthly means for water year 1938 during the months of July, August, and September, due to available storage capacity in Lake Chaplain and the first stage Sultan project.

VIII. WATER QUALITY CONTROL

A. NEED FOR CONTROL

1. General

The waters of the study area are subjected to a wide range of uses. Municipal water supply for the city of Everett, Snohomish, and Sultan are obtained from surface waters of the basin. Other uses which are dependent upon quality of the waters are fisheries, wildlife, and recreation.

2. Municipal and Industrial Water Supply

Surface waters of the study area are utilized quite heavily for municipal and industrial water supply purposes. Bacteriological and chemical quality of the Sultan and Upper Skykomish Rivers is considered to be very good. The Sultan River watershed is presently open for recreational activities which could possibly lead to a lessening in water quality. The city of Everett has recently been advised by the Washington State Health Department to close the watershed to public use or face the cost of providing complete treatment for the water supply which is now receiving disinfection.

3. Fisheries

The Snohomish River has limited spawning habitat for anadromous fish. It is primarily a migration route for upstream and downstream migrant salmon and steelhead between the ocean and the extensive spawning and rearing areas in the upstream tributaries. The river system supports large runs of chinook and coho salmon, medium size runs of chum salmon, small runs of pink salmon, and large runs of steelhead and sea-run cutthroat trout. Resident game fishes in the area consist of rainbow, brook, and cutthroat trout.

The tributary streams which are most important to spawning of anadromous fishes are the Pilchuck River, the Skykomish along with its North and South Forks, the Wallace River and the Sultan River below the Sultan Dam.

From data supplied by the Fish and Wildlife Service, the average annual commercial catch of anadromous fish produced by the Snohomish River Basin is shown alongside. The run of chum salmon has diminished to the point that the catch has been restricted to restore the population. Sport fisherman-days spent in angling for these and other species per year are also shown alongside.

Chinook Salmon	20,000 fish
Coho Salmon	55,000 fish
Pink Salmon	125,000 fish
Chinook	3,500 days
Coho	14,000 days
Pink	16,300 days
Steelhead Trout	100,000 days
Resident Species	400,000 days

4. Wildlife

Big game found in the Snohomish River Basin include sizable populations of black-tailed deer and black bear. Fewer numbers of mountain goat occur at high elevations in the eastern end of the basin. The basin provides suitable habitat for moderate populations of pheasant, quail, partridge, grouse and band-tailed pigeon. Approximately 400-500 hunter-days are expended for big game in the Sultan River watershed annually. Hunting pressure for upland game, particularly ring-necked pheasants, is intense. Fur-bearing animals include muskrat, mink, racoon, beaver, opossum, skunk, marten, otter, weasel, and fox. Snohomish County ranks third in the sale of trapping licenses in the State, but because of low pelt prices the economic value of fur animals is considered small. Because of mountainous terrain, waterfowl habitat is restricted, primarily to sloughs along the Lower Snohomish and Snoqualmie Rivers where considerable nesting and moderate waterfowl hunting occur.

5. Recreation

Recreational activities, other than fishing and hunting, of importance to the Snohomish Basin, are swimming, boating, picnicking, camping, and hiking. Although only one State park, Mt. Pilchuck, lies within the basin, there are two county recreation areas and many local picnic areas, particularly in those municipalities along major streams. Some 17 public campgrounds are maintained by the Federal, State, and local governments and private timber companies. Although much of the above mentioned activity is not of a water-contact nature, its value is considerably enhanced by the presence of a clean lake or stream. At the present time,

controlled recreational use is made of the Sultan River watershed. The city of Everett has recently been advised by the Washington State Department of Health to close the Sultan watershed to public recreation or incur the cost of providing complete treatment facilities for the city's water supply.

B. MUNICIPAL, INDUSTRIAL AND AGRICULTURAL POLLUTION

1. Present

Detailed data on all water-carried waste discharges and their disposal points are presented in Appendix A. Individual sources in this summary are listed in downstream sequence under the appropriate receiving watercourse. For purposes of this report, primary attention is given to the Sultan and Skykomish Rivers.

The major waste discharges in the Snohomish Basin are located in the Lower Snohomish River from the city of Snohomish to the mouth at Everett. Of the almost 54,000 people served by municipal sewerage in the basin, 48,000 or about 90 percent, are in the Lower Snohomish drainage area. Chief sources of the industrial wastes produced in the study area are the Weyerhaeuser kraft and sulfite plants, the Simpson Lee Paper Co., and the Scott Paper Co. Other sources of organic industrial wastes are seasonal fruit and vegetable canneries and milk and meat processing plants.

The present municipal and industrial waste loads for the Skykomish River drainage and the Snohomish River are summarized in TABLE VIII-1.

TABLE VIII-1
PRESENT STUDY AREA WASTE LOADS
Population Equivalents (PE)

Drainage Area	Municipal		Industrial		Total	
	Raw	Discharged	Raw	Discharged	Raw	Discharged
Skykomish	4,070	2,570	300	150	4,370	2,720
Snohomish	54,800	21,600	7,334,500	7,210,700	7,389,300	7,232,300

The Snohomish River is 22 miles in length with tidal influence extending to about River Mile 18. About 90 percent of the wastes of the present sewered population and 96 percent of the present industrial waste load in the entire Snohomish Basin are discharged to the lower 13 miles of the Snohomish River. Water quality problems have been encountered in this river reach due to these discharges. In 1960, the city of Everett constructed a sewage lagoon and interceptor sewers to eliminate discharge of untreated municipal wastes to the lower river. Partially treated industrial waste effluents from the pulp mills continue to cause occasional sludge beds, low dissolved oxygen and toxicity problems in the estuary area. Studies by the FWPCA Puget Sound Enforcement Project currently nearing completion are designed to determine the effect of these and related problems on passage of migratory fishes through Port Gardner Bay.

In addition to the direct water-carried waste discharges discussed above, another usually more subtle facet of water quality deterioration is related to land drainage and man's various activities in the watershed. Such essentially land-based operations as farming, road construction, logging, mining and recreation can cause quality deterioration in a number of ways. Other localized problems may be associated with return flows from the estimated 7,000 acres under irrigation by individual irrigators in the Snohomish Basin. For projection purposes, loads from land drainage are considered to be covered in the BOD of uncontrolled urban runoff. Return flow data for other similar areas and conditions indicate BOD to be relatively minor generally resulting in less than 1.0 mg/l in the receiving stream.

In preliminary classification of lands in the Snohomish Basin, the Bureau of Reclamation considers 23,900 acres as being potentially irrigable. If some of this land is developed for project type irrigation where return flows may be of significant quantity, then quality deterioration, particularly by pesticides, nutrients and turbidity may occur in the receiving stream. Good farming practices can provide control of these effects, thereby providing the equivalent of adequate treatment.

2. Future

In projecting 1980, 2000, and 2020 waste production for the Skykomish Basin, it is expected that population and industry will grow at the same rate as the population projected for the King

County ex-urban area and that adequate treatment to at least 85 percent BOD reduction will be provided. The projected waste production, together with the associated waste discharges after adequate waste treatment are shown in TABLE VIII-2.

TABLE VIII-2
PROJECTED WASTE LOADINGS FOR THE SKYKOMISH RIVER BASIN
Population Equivalents

	Municipal		Industrial		Total	
Year	Raw	Discharged	Raw	Discharged	Raw	Discharged
1980	8,140	1,220	600	90	8,740	1,310
2000	17,600	2,640	1,300	195	18,900	2,835
2020	46,200	6,950	3,280	490	49,480	7,440

Future growth in pulp and paper manufacturing and oil refining projected for the Snohomish Basin is expected to take place in the Port Gardner Bay vicinity. Population increase is also expected to center in the vicinity of Everett where the additional waste is expected to be collected and treated for discharge to Port Gardner Bay.

Projected waste loads for the pulp and paper and oil refining industries are shown in TABLE VIII-3.

TABLE VIII-3
PROJECTED PULP AND PAPER AND OIL REFINING WASTE LOADS
CENTRAL PUGET SOUND AREA

	Pulp and Paper		Oil Refining	
Year	Raw	Discharged*	Raw	Discharged*
1980	13,700,000	2,060,000	90,000	13,500
2000	18,300,000	2,360,000	145,000	21,800
2020	21,900,000	2,570,000	220,000	33,000

* Based on 85 percent BOD reduction.

C. WATER QUALITY OBJECTIVES

Water quality objectives for the various water uses to be served are discussed as follows.

1. Dissolved Oxygen

The dissolved oxygen (DO) objective for the Sultan and Skykomish Rivers is dependent upon anadromous fishery requirements--the use requiring the highest DO level. Other uses served at this level are recreation and aesthetic conditions.

Maintenance of 5 mg/l of dissolved oxygen would provide suitable conditions for anadromous fish passage while 7 mg/l provides adequate conditions for rearing. Spawning areas, however, require dissolved oxygen at saturation levels.

2. Temperature

Temperature requirements for the Snohomish and Skykomish Rivers are governed primarily by the anadromous fishery. Maximum temperatures should not exceed 70°F during July and August, to facilitate fish migration, holding and rearing; by mid-September, temperatures should not exceed 57°F to obtain optimum egg survival.

3. Bacteria

Bacterial objectives for recreation and raw municipal water supply use are 1,000 MPN and 5,000 MPN, respectively.

D. FLOW REGULATION

Prior to 1951 a barrier to the normal migration of salmon existed in the lower Snohomish River estuary and Port Gardner Bay. The barrier consisted of oxygen-deficient water in the river mouth during periods of low flow as a result of waste discharges from two large pulp mills at the river mouth. Construction of a deep water outfall in Port Gardner Bay to achieve better dilution and dispersion of untreated waste has done much to alleviate the problem. Studies by the FWPCA Puget Sound Enforcement Project currently nearing completion will assess the effectiveness of this disposal method.

Adequate water quality can be maintained in Snohomish River estuary by removal of settleable solids from pulp and paper mill waste effluents. Regulation of fresh water inflow to the estuary and to Port Gardner Bay would materially improve quality conditions in these areas.

For sections of the river above tidewater, computations utilizing oxygen balance techniques indicate that between 35 and 50 cfs will be required to receive the 2020 projected waste load (7,440 PE) and maintain minimum DO objectives (7.0 mg/1) for fishlife, recreation and other uses. More than adequate flow is presently available without regulation (minimum average daily flow of record, 315 cfs, November 29, 1952, near Gold Bar) to maintain these objectives.

Existing water right applications in the Skykomish River watershed total 3,663.81 cfs. If granted and fully exercised, water diversions associated with these rights would completely deplete streamflows during low flow periods, thus promoting possible future quality problems.

Lack of adequate temperature data for the Snohomish River Basin precludes judgment of the possible need for temperature control or of the potential temperature effects of the proposed projects on the Sultan and Skykomish Rivers. However, studies are being conducted in other basins by the FWPCA regarding the effects of impoundments on stream temperature, which may provide information at a later date applicable to the project under study.

As foreseen at this time, adequate treatment or control of waste at the source including effective disinfection of sanitary effluents will provide satisfactory control of water quality in the Sultan, Skykomish and Snohomish Rivers without specific release from storage from the Sultan Project for this purpose. These controls should be provided to maintain adequate quality conditions.

IX. BENEFITS

A. WATER SUPPLY - MUNICIPAL AND INDUSTRIAL

A future need for storage for municipal and industrial water supply exists in the study area. By the year 2020, 94,600 acre-feet of annual supplemental storage is expected to be required to meet the deficits incurred in the existing Everett system. Time of first need is estimated to be about the year 1975, or at approximately the same time as the Sultan Project is assumed to be completed.

For benefit computation purposes the value of storage for M&I supply in the Sultan Project is considered to be equal to the cost of the least-cost, most-likely, non-Federal, single-purpose alternative reservoir (enlargement) that could be constructed in the absence of the proposed Corps of Engineers' project. After considering the possibilities of another dam in the Sultan River watershed and a dam on the North Fork Skykomish River, it has been determined (based on cost data provided by the Corps of Engineers) that the most likely alternative would be single-purpose storage development on the Sultan River by enlargement of the present Sultan Dam.

The annual value of storage in the Sultan Project to yield 94,600 acre-feet of water annually for M&I supply at Everett has been determined to be $417,000 or $1,550 per mgd (based on an average annual yield of 270 mgd). This value includes annual operation and maintenance costs ($40,000), and is based on a 100-year amortization period at an interest rate of 3.125 percent, with time of first need beginning at the assumed time of project completion in 1975. In arriving at this value the capital cost ($11,500,000) of enlarging Sultan Dam to the second stage capacity was used.

B. WATER QUALITY CONTROL

As previously indicated, no requirements for storage for water quality control in the Sultan or Skykomish Rivers are foreseen at this time. No apparent damage to water quality is expected to occur as a result of operations of the enlarged Sultan Project. No positive or negative benefits can be assigned to storage in or operation of the proposed project. If unforeseen future development in the basin results in sustained minimum flows of less than 50 cfs, the adverse effects on water quality should be considered in evaluating the benefits of the proposed water withdrawals.

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APPENDIX

APPENDIX A

TABLE A-1

SURFACE WATER QUALITY

SNOHOMISH BASIN

Station		Discharge cfs	CATIONS mg/l Calcium Ca	Magnesium Mg	Sodium Na	Potassium K	ANIONS mg/l Chloride Cl	Sulfate SO_4	Fluoride F	Bicarbonate HCO_3	Dissolved Solids	Specific Conductance UMHOS	mg/l Silica SiO_2	Nitrate NO_3	Phosphate PO_4	Total Iron Fe	Turbidity JCU	Dissolved Oxygen mg/l	MPN E.Coli. Med.Value	Temp. °C	pH	Color
Skykomish River nr Gold Bar	Minimum	966	2.0	0.1	0.6	0.2	0.2	0.6	0.0	10	13	20	3.8	0.1	0.00	0.01	0	9.6	0.0	2.6	6.5	0
DA - 535 sq. mi.	Maximum	23,700	5.0	1.1	2.3	0.9	2.2	3.2	0.2	181	32	46	7.6	0.6	0.06	0.52	20	13.9	2,400	18.3	7.5	20
July 1959-March 1966	Mean	4,985.3	3.7	0.4	1.4	0.5	1.0	1.9	0.0	19	23	32	5.5	0.3	0.00	0.1	4	11.6	36	8.6	7.1	4.5
	Number	29	35	35	35	35	35	35	35	35	35	35	35	30	33	33	15	35	35	35	35	35
Sultan River at Sultan	Minimum	--	2.0	0.1	0.6	0.1	0.2	0.6	0.0	9	16	20	2.6	0.1	0.00	0.01	0	8.5	0	3.5	3.9	0
DA	Maximum	--	9.0	2.4	3.3	0.9	1.8	4.8	0.1	38	56	73	10.0	0.8	0.07	2.0	75	13.7	930	21.3	8.1	15
July 1960-March 1966	Mean	--	4.6	0.8	1.2	0.3	0.8	2.8	0.0	17	27	38	5.2	0.3	0.01	0.37	22	11.2	36	9.6	7.0	7.1
	Number	--	33	33	33	31	33	33	31	33	33	33	33	33	31	31	16	33	33	32	33	33
Snoqualmie River at Snoqualmie	Minimum	134	1.5	0.1	0.7	0.1	0.2	0.4	0.0	7	14	16	3.1	0.1	0.00	0.02	0	9.0	0	3.2	6.2	5
DA	Maximum	2,610	6.0	1.0	1.8	0.8	1.5	3.0	0.2	22	33	46	7.9	1.8	0.12	4.0	40	13.2	4,600	17.5	7.4	40
July 1959-March 1966	Mean	779.3	4.1	0.4	1.2	0.4	0.7	2.1	0.0	15	24	32	5.7	0.4	0.02	0.54	11	11.0	840	9.1	6.9	8.2
	Number	15	33	30	33	33	33	32	33	33	33	33	33	32	31	31	14	32	32	32	33	33
Tolt River at Carnation	Minimum	90	3.0	0.3	1.0	0.1	0.2	2.2	0.0	10	21	24	3.8	0.1	0.00	0.03	0	8.7	0	3.7	6.6	0
DA-81.4 sq. mi.	Maximum	2,340	8.0	1.9	2.1	0.7	1.2	5.6	0.1	32	47	65	10.0	1.0	0.03	1.0	50	14.7	430	23.2	7.5	30
July 1960-March 1966	Mean	697.9	5.2	0.9	1.6	0.2	0.8	2.7	0.0	19	33	43	7.2	0.4	0.00	0.3	13	11.0	36	10.6	7.1	11.2
	Number	27	33	33	33	30	33	33	33	33	33	33	33	33	31	31	15	32	31	31	33	33
Snohomish River at Snohomish	Minimum	10,000	2.0	0.2	0.8	0.1	0.2	0.8	0.0	10	14	20	3.3	0.1	0.00	0.04	0	8.3	23	4.0	6.7	0
DA-1,720 sq. mi.	Maximum	40,800	7.2	1.6	3.1	0.9	2.2	4.0	0.2	27	40	62	11.0	2.6	0.12	3.0	160	14.0	24,000	19.0	7.4	20
August 1959-April 1966	Mean	18,710.5	4.5	0.9	1.8	0.52	1.2	2.8	0.1	18	30	41	6.5	0.8	0.02	0.35	13	11.1	930	12.1	6.9	6.8
	Number	19	55	55	55	54	55	55	55	55	55	55	55	54	54	45	42	53	52	53	55	53

APPENDIX A

TABLE A-2
GROUND WATER QUALITY
KING AND SNOHOMISH COUNTIES

Owner	Well Location Code	Date	Temp °F	PARTS PER MILLION											
				Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Nitrate (NO_3)	Ortho-Phosphate (PO_4)	Dissolved Solids 1/	Hardness (as $CaCO_3$)	Specific Conductance 2/	pH
KING COUNTY															
King County Water Dist. #64	21/4-5Q2	12/18/59	50	19	4.4	14	5.3	5.8	2.6	0.2	0.09	102	57	157	7.6
Boeing Aircraft Co.	23/4-4A1	4/19/54	56	25	0.14	-	-	114	8.4	1.0	-	812	-	1600	-
King County Water Dist. #82	24/6-4N1	4/ 3/58	48	34	1.0t	10	4.6	4.2	3.3	3.3	-	96	44	106	7.2
City of Issaquah	24/6-27Q1	8/20/51	50	17	0.07	22	3.5	7.4	1.8	0.1	-	109	69	162	8.0
Darigold Farms	24/6-28J1	8/20/51	-	22	0.01	10	3.3	5.4	1.6	3.5	-	84	38	105	7.0
Fall City Water Co.	24/7-11L1	8/20/51	-	47	1.6t	20	6.8	6.6	3.4	0.2	-	143	78	175	7.7
City of Redmond	25/5-12C1	3/24/59	40	23	0.06	10	4.7	4.9	1.1	5.6	-	82	44	116	7.3
Carnation Farms	25/7-6R1	10/ 6/60	54	27	1.1	22	9.2	22	4.2	0.0	0.58	176	93	269	8.0
Bothell Water District	26/5-5E1	8/24/51	-	47	0.03	21	8.4	8.6	4.0	0.7	-	158	87	201	7.2
City of Duvall	26/6-13D1	10/ 6/60	50	16	.11	24	5.8	32	2.2	0.8	0.47	179	84	290	8.1
SNOHOMISH COUNTY															
City of Edmonds	27/3-24Q3	12/18/59	-	36	0.00	9.5	9.4	5.9	2.1	3.3	0.21	113	62	160	7.6
Alderwood Manor Water Dist.	27/4-10N1	12/ 1/59	50	45	0.00	13	6.1	7.8	2.7	0.2	0.60	123	58	156	7.7
Snohomish County PUD #1	28/5-7G2	10/13/60	51	31	0.05	10	10	5.9	1.1	6.9	0.1	115	67	162	7.5
City of Marysville	29/5-2C1	12/18/59	48	25	0.81	18	7.5	6.1	1.3	0.2	0.69	118	76	179	7.8
Potlatch Beach Water Dist.	30/4-15R1	10/ 5/60	49	40	0.89	36	19	11	3.4	2.0	0.43	229	170	364	7.4
City of Arlington	31/5-2L1	4/27/61	48	8.5	0.08	9.0	3.5	2.2	0.7	0.7	0.00	58	37	86	7.2

1/ Residue on evaporation at 180° C

2/ Micrombos at 25° C

Iron: Total iron concentrations are followed by a "t." All other values represent iron in solution at the time of sample collection.

Source: GROUND WATER IN WASHINGTON, ITS CHEMICAL AND PHYSICAL QUALITY, Water Supply Bulletin No. 24, Washington State Department of Conservation, 1965.

APPENDIX A

MUNICIPAL AND INDUSTRIAL WASTES INVENTORY

SNOHOMISH RIVER BASIN

Receiving Water Course & Municipality or Separately Discharging Industry	River Miles Above Mouth	1960 Population	Est. Pop Served	Estimated PE of Waste Before Treatment	Treatment Provided	Estimated PE Discharged to Watercourse	Seasonal Waste PE Raw	Seasonal Waste PE Disc.	Remarks
Snohomish-Skykomish River									
Index	51.4	158	170	170	None	170			
S. Fk. Skykomish River	50.0								
Stevens Pass Rec. Area									
Skykomish	49-8	366	X	X	No System	X			Primarily winter use
Grotto	49-4	X	X	X	No System	X			Unincorporated small hamlet
Ideal Cement Co.				Inorganic					
Gold Bar	40	315	X	X	No System	X			
Sultan	35	821	500	500	None	500			Grant applied for May 1966
Monroe	25	1,901	1,950	2,400	Primary	1,800			
Sky Valley Meat Co.				300	Primary	150			
State Reformatory		X	1,000	1,000	Lagoon	100			
Snoqualmie River	20.7								
S. Fk. Snoqualmie River	20-45								
Snoqualmie Pass Rec. Area	20-45-28	X	X	4,000	None	4,000			Planning Construction 1966
North Bend	20-45-2	945	900	1,200	Primary	840			
Snoqualmie	20-42	1,216	900	900	Lagoon	100			
Snoqualmie Falls		X	300	300	Primary	100			
Weyerhaeuser Co.		X	X	5,000	Pond	500			14 mgd water used on market
Fall City	20-36	X	X	X	X	X			
Carnation	20-25	490	X	X	No System	X			
Duvall	20-14	345	X	X	No System	X			
James Wallace Meat Pkg. Co.		X	X	400	Primary	200			5 Beef 1 day/week
Pilchuck River	13.7								
Granite Falls	14-16	599	600	600	Primary	420			
Little Pilchuck River	14-9.3								
Lake Stevens	14-9-3				No System				
Berry Valley Farm Pak				Seasonal	None		5,000	5,000	June-July--50T strawberries, 20T raspberries
Snohomish	11	3,894	4,000	8,400	Lagoon	1,500	89,000	20,000	June-July
Berryland Packers Inc.		X	X	Seasonal			(3,000)	(X)	June-July
Clancy's Frozen Sticks		X	X	(1,000)	City Sewer	(X)			
Snohomish Co. Dairymens Assn.		X	X	(1,800)	City Sewer	(X)			
Evergreen Frozen Foods				Seasonal	City Sewer		(45,000)	(X)	July-September
Ferguson Canning Co.				(500)	City Sewer	(X)			
Hershey Packing Co.				Seasonal	City Sewer		(30,000)	(X)	June-August
Puyallup & Sumner Sales Co.				Seasonal	City Sewer		(2,000)	(X)	June-July
Snohomish Meat Co.				700	Septic Tank	300			
Ebey Slough	8.3								
Marysville		3,117	3,000	3,000	Lagoon	450	5,000	450	
Snohomish Co. Berry Growers		X	X	Seasonal	(Lagoon)		(2,000)	(X)	June-July, 10T strawberries
Jansha Tanning Co.		X	X	600	Lagoon	300			
Lowell	7.0	1,086	(1,000)	(1,000)	Everett Lagoon	(X)			
Simpson Lee Paper Co.		--	X	75,000	Swamp	50,000			271 T/day
Everett	3.3	40,304	41,000	45,000	Lagoon	20,000			
Foremost Dairy				(450)	City Sewer	(X)			
Scheerer Canning Co.				(450)	City Sewer	(X)			
Puget Sound By Products	2.5			1,000	None	1,000			
Federal Packing Co.	2.5			2,400	None	2,400			
Weyerhaeuser Lumber Mill	1.3			10,000	None	10,000			
Weyerhaeuser Kreft Div.				240,000	Pond	237,000			To Steamboat Slough
Everett Fish Co.				600	None	600			
Scott Paper Co.				4,740,000	Deep Water Outfall	4,740,000			Deep Water Outfall
				155,000	Clarifier	57,100			New Survey, June 1966
				125,000		125,000			Main Mill - No Treatment
Weyerhaeuser Sulfite				1,980,000		1,830,000			Deep Water Outfall
						156,000			To Inner Harbor
Boeing Assembly Plant									Under Construction 1966
Mukilteo		1,128	1,200	1,300	Primary	460			To Puget Sound
Paine Air Force Base				1,300		200			To Puget Sound

Lake Goodwin
Lake Shoecroft
TULALIP INDIAN RESERVATION
Marysville
Granite Falls
SARATOGA PASSAGE
PORT GARDNER
PILCHUCK
CITY OF SNOHOMISH DIVERSION DAM
RIVER
Sloan Peak 7,799
WHIDBEY ISLAND
EVERETT
Lake Stevens
Roesiger Lake
Lake Chaplain Reservoir
WOODS CR
SULTAN
RENEY CR
PROPOSED SULTAN DAM PROJECT ENLARGEMENT
SNOHOMISH
Snohomish
Sultan Startup
Gold Bar
NORTH FORK
Soda Springs
SNOHOMISH COUNTY
CHELAN COUNTY
PUGET SOUND
POSSESSION SOUND
Monroe
SKYKOMISH
RIVER
Index
BECKLER
RIVER
Edmonds
Mountlake Terrace
SNOHOMISH COUNTY
KING COUNTY
SOUTH FORK
Richmond Highlands
Duvall
NORTH FORK
SOUTH FORK
TYE RIVER
Skykomish
SNOQUALMIE
TOLT-SEATTLE WATER SUPPLY DAM PROJECT
TOLT RIVER
FORK
SEATTLE
Carnation
SNOQUALMIE FALLS HYDROELECTRIC PROJECT
NORTH FORK
FOSS RIVER
MT. Daniel 7986
Fall City
Dorothy Lake
Sammamish Lake
LAKE WASHINGTON
Preston
Snoqualmie Falls
SNOQUALMIE RIVER
Snoqualmie
North Bend
RAGING RIVER
MIDDLE FORK
KING COUNTY
KITTITAS COUNTY
Snoqualmie Mt. 6270
Renton
CEDAR RIVER
SOUTH FORK
CEDAR RIVER HYDROELECTRIC PROJECT
CITY OF SEATTLE DIVERSION DAM
Chester Morse Lake
STUDY AREA
SEATTLE
WASHINGTON
VICINITY MAP
5 0 5
SCALE IN MILES
WATER SUPPLY & WATER QUALITY CONTROL STUDY
SNOHOMISH RIVER BASIN, WASHINGTON
LOCATION MAP
UNITED STATES DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
NORTHWEST REGION DATE (8/67) PORTLAND, OREGON